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Spruce Budworm in the Western United States

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Spruce budworm, *Choristoneura fumiferana* (Clem.), is the most widely distributed and destructive forest insect in North America. It is found from Virginia north to Labrador, west across Canada and northern United States to the Pacific coast, as far north as the 67th parallel in the Northwest Territories, and south into northeastern California and southern New Mexico. Its distribution in the Western United States is shown in figure 1.

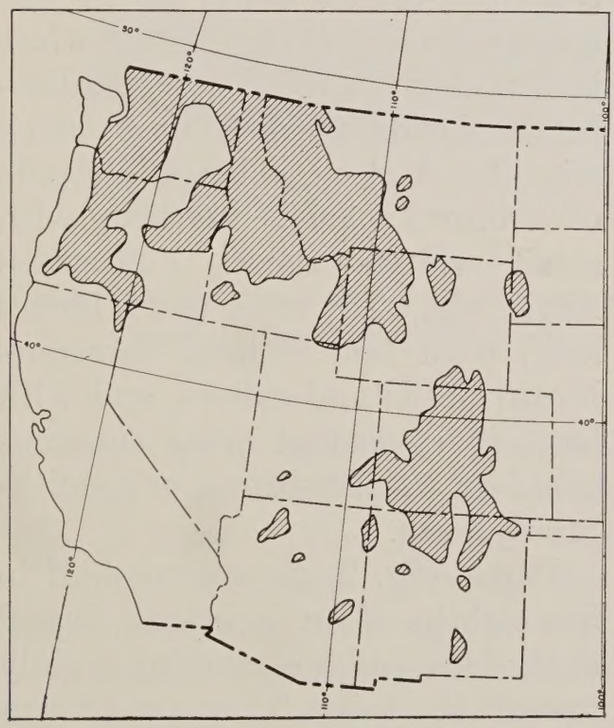

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Figure 1.—Distribution of spruce budworm in the Western United States.

The first recorded outbreak of the spruce budworm in western North America occurred in 1909 on the southeastern part of Vancouver Island in British Columbia. Since that year, infestations have frequently been reported in western Canada.

Although known to be present in Oregon since 1914, the budworm was not recognized as a serious enemy to forests in the Western United States until 1922, when two distinct outbreaks occurred in Idaho. Widespread, destructive epidemics have since been recorded in many forests in the Rocky Mountains and in the Pacific Northwest.

Before 1944, spruce budworm epidemics in the Western United States generally lasted from 3 to 5 years and then subsided from natural causes. Since 1944, continuing epidemics have occurred in Idaho, Montana, and Oregon. However, aerial spraying programs, started in 1949, have effectively controlled the budworm in the heaviest centers of infestation, gradually reduced the extent of the epidemics, and prevented the destruction of valuable forest resources.

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Experience with spruce budworm infestations in the Western United States has shown that subsequent tree killing by bark beetles in heavily defoliated stands may add considerably to the loss. These attacks, primarily by the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.), sometimes reach widespread proportions, extending beyond the budworm infestation into healthy stands.

Host Trees

Despite its name, the spruce budworm feeds on many coniferous species, several of which are preferred to spruce. Tree species damaged by the budworm in the Western United States may be grouped as follows:

Preferred hosts	*Common hosts*
grand fir	blue spruce
white fir	lodgepole pine
Douglas-fir	ponderosa pine
subalpine fir	
Engelmann spruce	

Occasional hosts

western larch	corkbark fir
western hemlock	limber pine
western juniper	western white pine
white spruce	

New foliage of the host tree is preferred, and trees of all ages are defoliated. The greatest economic damage has occurred in stands of the preferred hosts.

There appear to be several races or varieties of spruce budworm in the Western United States. Some of these, for example the budworm that attacks pure pine stands, may even be a species other than *Choristoneura fumiferana*. Further study is needed to relate variations in feeding and oviposition characteristics of the budworm with actual physical differences.

Description

In all its life stages, the spruce budworm on its preferred hosts in the West is larger than its counterpart in the East. Adult moths (fig. 2, *A*) are almost one-half inch long and have a wingspread of ⅞ to 1⅛ inches. The gray or brown wings are marked with bands or streaks and each usually has a conspicuous white dot. Eggs are oval, light green, and about a sixteenth of an inch long. They are deposited in masses on the undersides of the needles, with individual eggs overlapping like shingles (fig. 2, *B*).

Usually there are six larval instars. Upon hatching, the larvae are green with brown heads. During the next three instars the larvae (fig. 2, *C*) have black heads and collars and an orange-brown or cinnamon-brown body, as in the eastern form. In the next to last instar, the larvae have reddish-brown heads marked with black triangles, a black collar, and a pale olive-brown body, marked with small whitish spots. Full-grown larvae (fig. 2, *D*) are 1 to 1¼ inches long, with tan or light chestnut-brown heads and collars, and with large ivory-colored areas superimposed on an olive-brown or reddish-brown body.

Pupae (fig. 2, *E*) are one-half to five-eighths of an inch long, broad at the head end but tapering rapidly toward the tail. They are brownish yellow when first formed and later turn reddish brown.

Evidence of Infestation

Evidence of an infestation varies with the season of the year. In spring, the small larvae mine the

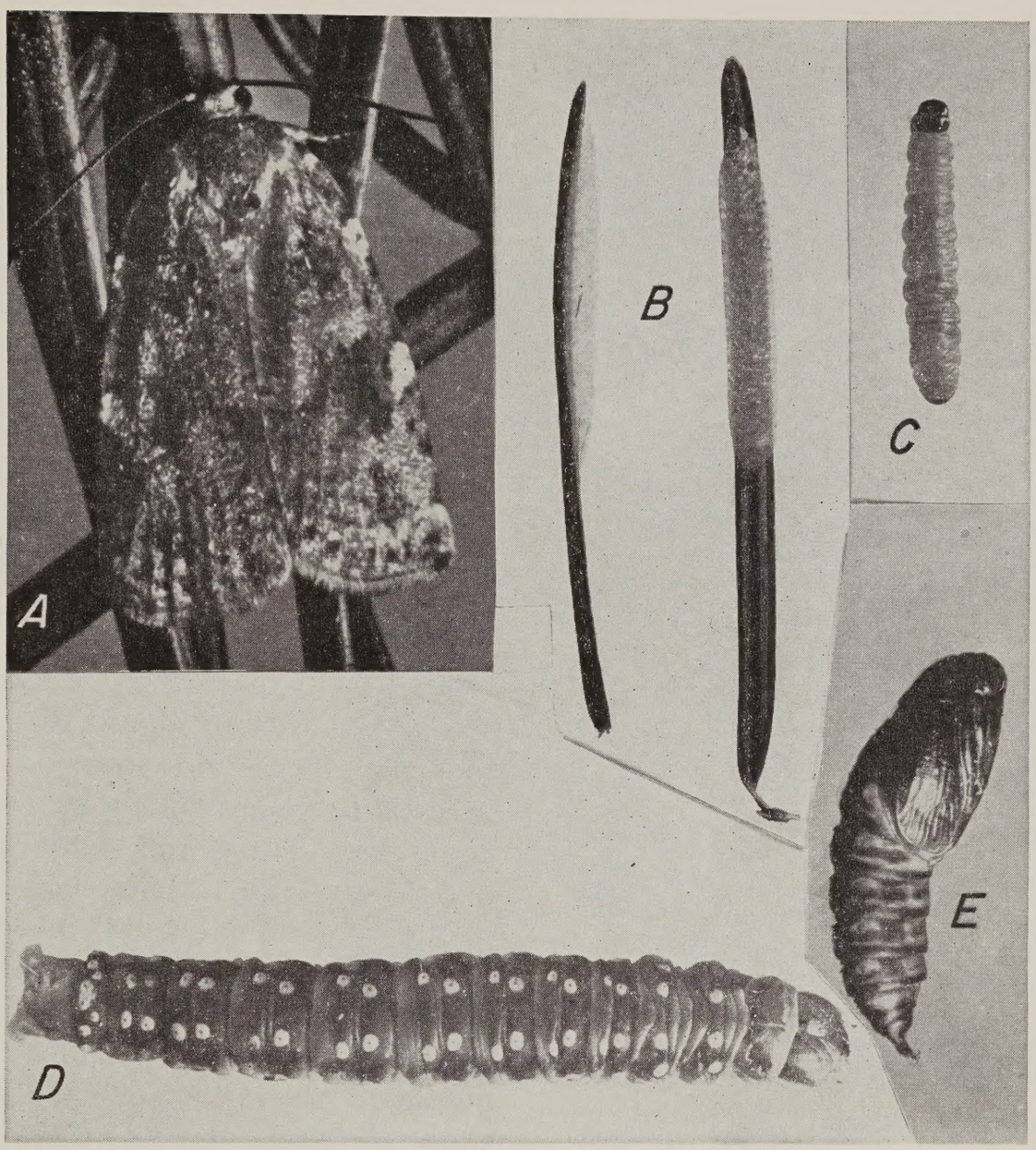

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Figure 2.—Life stages of the spruce budworm: *A*, Adult; *B*, egg masses; , *C*, fourth instar larva; *D*, sixth instar (full-grown) larva (head at right); *E*, pupa. (All X3.)

needles (fig. 3) and later enter the swelling buds (fig. 4). As shoot growth starts, larval feeding may cause malformation. During July, webbed branch tips (fig. 5) that turn reddish brown usually indicate the presence of full-grown larvae. When infested stands are viewed from vantage points, the trees appear to have been singed by a light crown fire. After the discolored foliage has fallen, the bare tips indicate that budworm feeding has occurred.

Unless a large percentage of new foliage is destroyed, a spruce budworm infestation causes no serious damage to trees. Furthermore, unless repeated, severe defoliations occur for a period of 3 to 5 years or longer, trees recover. During outbreaks larvae may destroy practically all the new needle growth and a large proportion of buds and new shoots. Young-growth fir stands suffer heavy damage, and understory trees in particular are severely defoliated (fig. 6). After a period

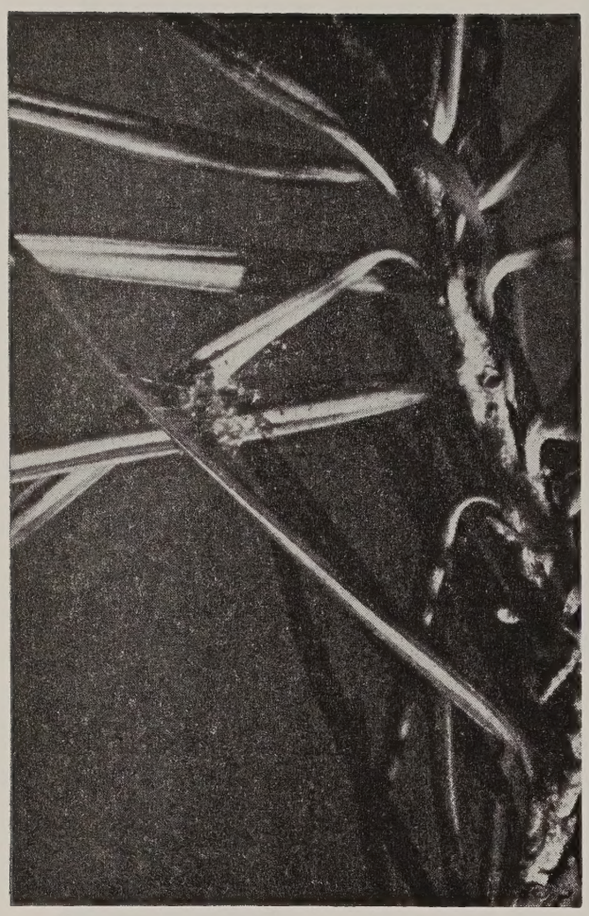

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Figure 3.—Silken threads and frass around entrance hole made by a spruce budworm larva during needle-mining period.

of sustained attack many trees may be almost entirely defoliated, with growth sharply reduced. Some trees will be starting to die.

In the mountainous areas of the West, late spring frosts often kill the tender new shoots of firs. This killing may be mistaken for work of the spruce budworm. If close inspection reveals no partially eaten needles and webbing, the damage is probably due to frost.

Usually one or more other species of defoliators, normally of little economic importance, are associated with spruce budworm. In feeding and appearance, some associated species closely resemble spruce budworm. Technical assistance should be sought in differentiating between the budworm and associated insects.

Life History

In most of its range, the spruce budworm develops from egg to adult in 12 months. However, in parts of western Canada and in some high-elevation stands in the Western United States, the budworm requires 24 months to complete its development.

In the normal 1-year life cycle, moths emerge from pupal cases late in July or early in August and the females deposit egg masses. A female lays approximately 150 eggs in masses of a few to 130 eggs, and averaging 40 to 45 eggs per mass. The eggs hatch in about 10 days. The tiny larvae do not feed but seek hiding places among lichens or under bark scales and similar protective material. Here they spin silken webs (hibernacula) in which they remain dormant over winter.

In spring the larvae move to the foliage where they tunnel into needles. About the time the buds start to swell, larvae leave the needles and bore into the expanding buds. In some parts of the West they move directly from hibernation to the vegetative buds or male and female flowers. As the new shoots unfurl, the larvae spin loose webs between the needles and tips. Within the webs they feed on the new foliage. New growth is usually entirely destroyed before larvae feed on older needles. When full grown, larvae usually change to pupae within these webs; however, some larvae spin webs and transform to adults in other places on the tree. Needle-mining ordinarily lasts 7 to 14 days. Feeding on buds and new shoots lasts 30 to

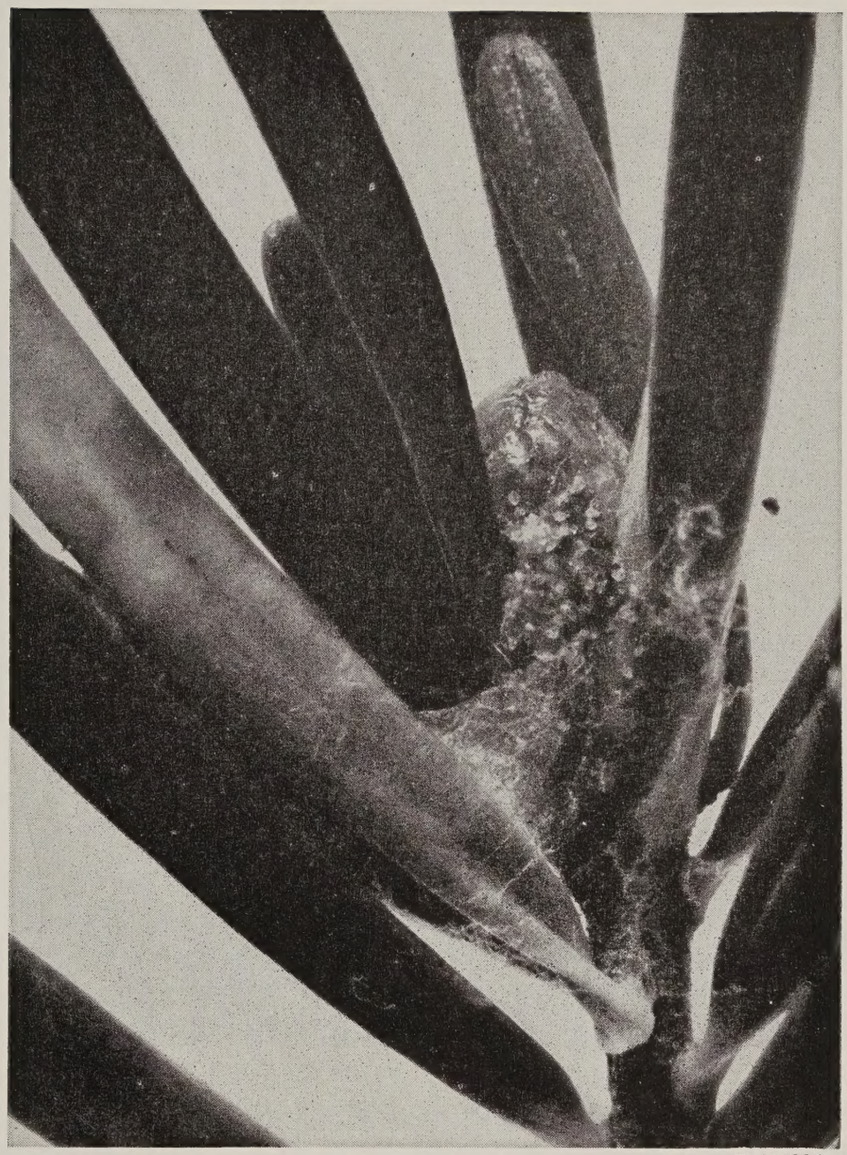

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Figure 4.—Evidence that a spruce budworm larva has entered a swollen bud.

40 days before pupation takes place. Although adult moths are sluggish fliers, they may be carried great distances by air currents. Normally the female deposits its eggs within 7 to 10 days after emergence and then dies.

In a 2-year life cycle, development of the budworm is the same as that in the 1-year cycle, until the larvae are about half grown. Instead of maturing, larvae hibernate in protected places for a second winter. During the second season larvae complete their feeding and pupate. Adults then emerge and lay eggs. The amount of defoliation is relatively light during the first season of a 2-year cycle because larvae are small. During the second season, when larvae reach full growth, defoliation is much more serious.

Natural Control

Spruce budworm populations are normally held in check by combinations of several natural control factors: parasites, predators, diseases, and adverse climatic conditions. However, when conditions are favorable for the budworm's increase, the combined effect of all natural factors cannot be relied upon to prevent an outbreak and possible serious damage to susceptible stands. During prolonged outbreaks, starvation can be an important factor in controlling budworm populations.

Approximately 70 species of pri-

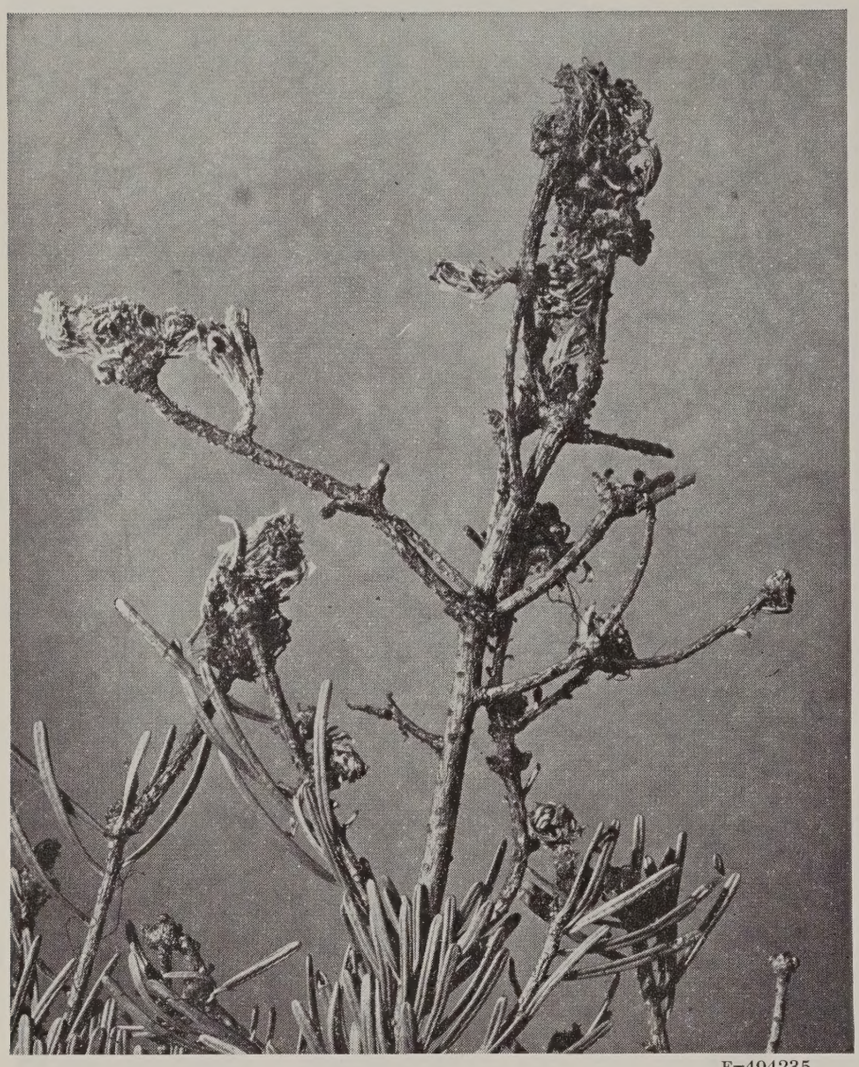

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Figure 5.—Tips of white fir defoliated and webbed together by full-grown spruce budworm larvae.

mary parasites (small wasps and flies) have been recovered from the spruce budworm throughout its range in North America. In the Western United States about 35 species of primary parasites are known, with some 10 to 12 species exerting the most control. Two important parasites are shown in figures 7 and 8.

Spiders, mites, ants, and larvae of certain beetles are important predators of the budworm. Warblers, thrushes, sparrows, cedar waxwings, and evening grosbeaks are the more important birds feeding on the budworm.

Budworm mortality from diseases has been very low, even though the budworm has been found infected by several pathogens.

Climatic conditions may affect the budworm in several ways. Extreme temperature changes could have a marked effect on overwintering larvae in both 1- and 2-year life cycles. Sudden freezing temperatures in spring may kill larvae in needles, buds, or webbed new foliage. Prevailing winds and storms may disperse moths over wide areas.

Applied Control

In the West, little research has been done on indirect control of the spruce budworm through forest management practices. Because the budworm attacks trees of all age classes and because the preferred host tree species are closely intermingled, little hope is held for such methods of control.

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Figure 6.—Feeding of spruce budworm on this young-growth Douglas-fir stand has resulted in severe defoliation.

Under forest conditions, excellent direct control of spruce budworm populations can be obtained by aerial application of a formulation of 1 pound of DDT dissolved in 1.25 quarts of a hydrocarbon solvent, with enough fuel oil added to make 1 gallon of solution (fig. 9). When applied to large larvae at a rate of 1 gallon per acre during calm and cool morning hours, upward of 95 percent mortality can be obtained.

The question of whether to apply direct control measures against the spruce budworm should be decided only after careful consideration of (1) the current effectiveness of natural control, (2) the amount and nature of damage caused and expected to occur, and (3) the economic values at stake. Some outbreaks are curbed by natural control factors before serious damage occurs; others continue to expand and cause widespread damage. The values at stake, such as watershed, recreation, or timber resources, must be weighed against the cost of a control operation.

To be successful, a control project requires (1) a thorough aerial and ground survey to delineate necessary buffer zones and the extent and severity of infestations, and (2) a well-trained and well-organized team of administrators, entomologists, safety advisers, technicians, and qualified pilots. Spray planes must be adequately powered and equipped.

During the 10-year period 1949–58, more than 9 million acres of epidemic infestation have been treated in the Western United States at an average cost of about $1 per acre. To date, only a small percentage of this area has required respraying.

Spruce budworm attacks on individual trees or small groups of trees can be controlled with a 12-percent solution of DDT in fuel

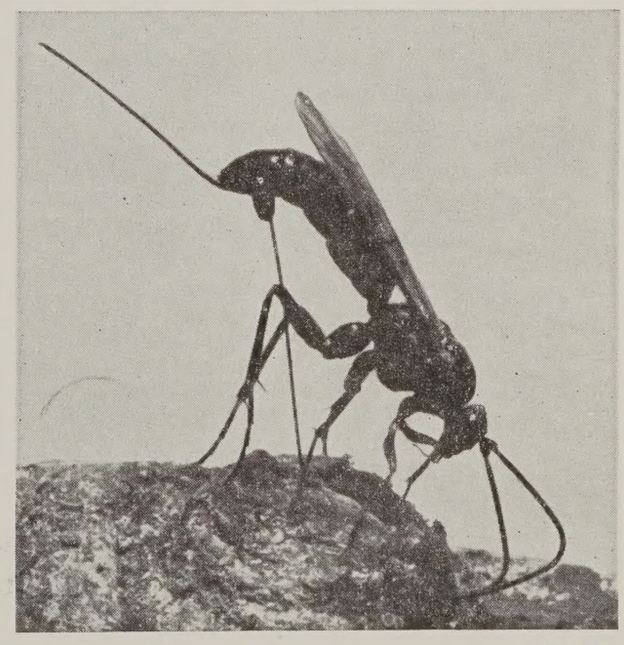

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Figure 7.—Adult of the parasite ***Glypta fumiferanae*** (Vier.) ovipositing in body of overwintering spruce budworm larva, concealed within a twig scar.

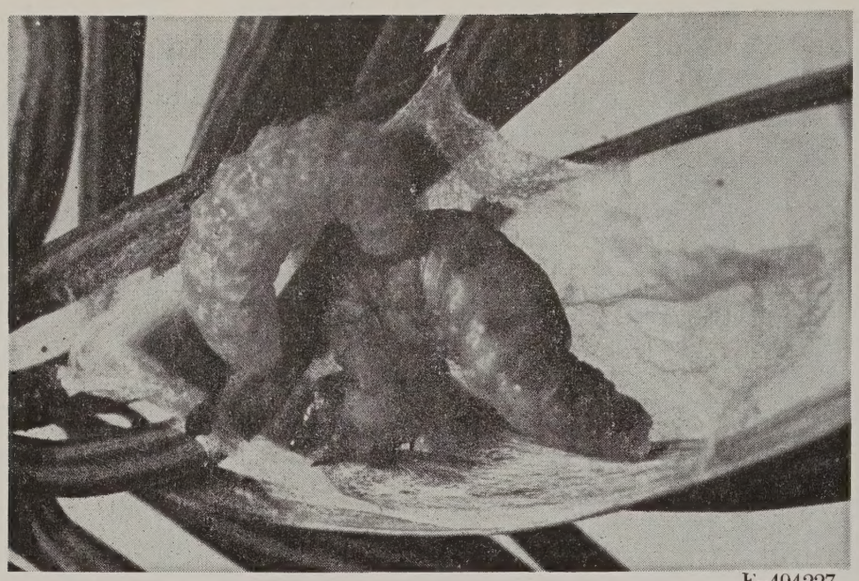

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Figure 8.—Full-grown larva of an external parasite, ***Phytodietus fumiferanae*** Rohw., completing its feeding by killing the host, a sixth instar spruce budworm larva.

oil, applied with knapsack-type or power sprayers. To prevent destruction of new foliage by the budworm, two applications may be necessary. One should be directed against small larvae about the time the buds begin to unfurl. A second should be directed against full-grown larvae, before pupation.

Caution: DDT is poisonous and should be used with adequate precaution. Store in a safe place, away from food and correctly labeled. Use care in applying DDT and avoid excessive amounts, especially in aerial spraying around lakes and streams.

Figure 9.—DC-3 spraying DDT to control spruce budworm.

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